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THE ULTRASONIC/SONIC DRILLER/CORER (USDC) AS A SUBSURFACE DRILL, SAMPLER AND LAB-ON-A-DRILL FOR THE MARS ASTROBIOLOGY SCIENCE AND TECHNOLOGY

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The search for existing or past life in the Universe is one of the most important objectives of NASA's mission. For this purpose, effective instruments that can sample and conduct in-situ astrobiology analysis are being sought. In support of this objective, a novel Ultrasonic/Sonic Driller/Corer (USDC) based mechanism has been developed to probe and sample rocks, ice and soil. The USDC consists of an ultrasonic actuator that impacts a coring or drilling bit at sonic frequencies through the use of an intermediate free mass. The USDC can produce both a core and powdered cuttings as well as emit elastic waves. For planetary exploration, this mechanism has the important advantage of requiring low axial force, virtually no torque, and can be duty cycled to require as low power as 2-W. This low axial load advantage overcomes a major limitation of planetary sampling in low gravity environments and when operating from lightweight robots and rovers. The low power operation produces a minimum temperature rise which is required for the acquisition of biologically meaningful samples.

The development of the USDC is being pursued on various fronts ranging from analytical modeling to mechanisms improvements while seeking a wide range of applications. While developing the analytical capability to predict and optimize its performance, efforts are made to enhance its capability to drill at higher power, high speed while operating quietly. Taking advantage of the fact that the bit does not turn and that it is only subjected to minute displacements, sensors (e.g., thermocouple and fiberoptics) were integrated into the bit to examine the borehole during drilling. The sounding effect of the drill was used to emit elastic waves in order to evaluate the surface characteristics of rocks. As a corer, samples were made from various rocks, including basalt and limestone, at dimensions that are as large in diameter as 5-cm and as long as 10-cm. Studies conducted in conjunction with CHEMIN (Chemical and Mineralogy analysis) task, showed that the produced micron size powdered cuttings had dimensions that are ideal for X-Ray Diffraction (XRD) analysis. To take advantage of the low axial load requirement of the USDC, a 4-legged walking robot is currently being developed to climb steep rocks using a USDC on each of the legs to anchor the rover to the rocks while climbing. Upon completion of this task, the possibility of walking on concrete ceiling will be considered. For deep surface penetration, a U/S gopher that is 5-cm in diameter and about 1-m long is being developed to reach as deep as 20-m at -20^{o}C ice in Lake Vida, Antarctica. The scaling of the USDC is also an issue that is being investigated, where besides the U/S gopher we are considering the development of a U/S jackhammer. In this paper, the latest status of the USDC development and applications that are underway will be reviewed.

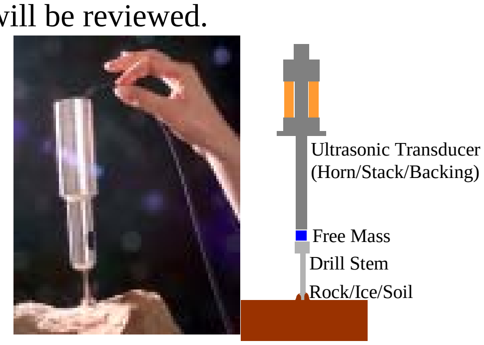

FIGURE 1: The USDC is shown coring with minimum axial force and holding torque (left), and a schematic diagram of the USDC components (right).